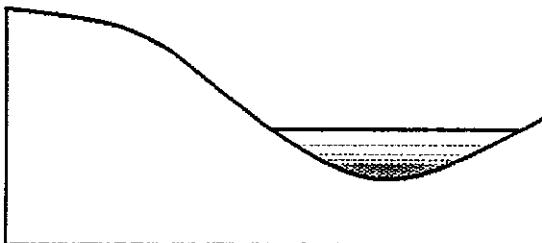


Turkey Flat, USA

Site Effects Test Area

REPORT 4

Weak-Motion Test: Observed Seismic Response



July 1990

TECHNICAL REPORT NO. 90-1

CALIFORNIA DEPARTMENT OF CONSERVATION

DIVISION OF MINES AND GEOLOGY

EARTHQUAKE SHAKING ASSESSMENT PROJECT



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DEPARTMENT
OF CONSERVATION

Division of Mines and Geology

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The Turkey Flat site effects test area is one of a series of international test areas endorsed by the International Association of Physics of the Earth's Interior and the International Association of Earthquake Engineers.

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**TURKEY FLAT, USA
SITE EFFECTS TEST AREA**

Report 4

Weak-Motion Test: Observed Seismic Response

Prepared by

Chris H. Cramer and Charles R. Real

July 1990

**TECHNICAL REPORT NO. 90-1
CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY
EARTHQUAKE SHAKING ASSESSMENT UNIT**

**Turkey Flat, USA
Site Effects Test Area**

OVERVIEW

NEEDS The 1985 Mexico City and 1989 Loma Prieta earthquakes are our most recent reminders that local ground conditions can have a strong influence on where damage will occur in urbanized areas during an earthquake, and underscores the need to incorporate seismic shaking potential in land-use decisions. Although several different methods for making such assessments are currently in use, their accuracy and costs are not well known. Reliability and cost of methods must be known before they can be routinely used to provide a sound basis for safer land-use and construction practices.

GOALS The principal goals of the Turkey Flat Site Effects Test Area are to systematically compare and determine the reliability of contemporary methods used to estimate the effect of local geology on earthquake shaking, and to test the linearity of shallow stiff-soil site response.

OBJECTIVES Principal objectives are to collect high quality weak- and strong-motion data at several locations in the test area produced by local and regional earthquakes, quantify the site geology in terms of its geotechnical properties, and distribute the information to experts around the world.

APPROACH Using the acquired data, a series of "blind" predictions will be made by ground motion experts for test area locations where the response will be known, but not be available until all predictions have been received. Results of each prediction will be compared with one another and with actual observed ground motion.

PRODUCTS A series of reports describing each principal phase of the project will be available as the work progresses. An evaluation of all site response estimation methods will be prepared with recommendations as to suitability and cost of routine application for urban earthquake shaking hazard assessment.

Acknowledgments

Special recognition is due the following agencies, companies and corporations for their support and advice: California Department of Transportation, Dames & Moore, Electric Power Research Institute, Geomatrix Consultants, Geospectra, Harding Lawson Associates, Kajima Corporation, LeRoy Crandall Associates, OYO Corporation, Pitcher Drilling Company, Redpath Geophysics, U.S. Geological Survey, and Woodward-Clyde Consultants. We also wish to thank the California Department of Conservation's Strong-Motion Instrumentation Program for assistance in processing the test data, and Lawrence Livermore National Laboratory for loan of field recording equipment.

Most of all, we are grateful for the cooperation of Donald and Nila McCornack, owners of the land on which the Turkey Flat array is located.

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FOREWORD

IASPEI/IAEE Joint Working Group

At the 1985 meeting of the International Association of Seismology and Physics of the Earth's Interior (IASPEI), held jointly with the International Association of Earthquake Engineering (IAEE) in Tokyo, Japan, a resolution was passed forming the IASPEI/IAEE Joint Working Group on The Effects of Local Geology on Seismic Motion. The purpose of this group is to coordinate the establishment of an international series of test areas designed to provide a data base for comparing and testing contemporary methods, and developing new methods, to predict the effects of local geology on ground motion caused by earthquakes. The 1985 Michoacan and 1989 Loma Prieta earthquakes are only the most recent reminders that local ground conditions can have a major influence on where damage will occur in major earthquakes. Although methods for assessing site effects are being used to construct critical facilities around the world, the reliability of these methods has not been rigorously tested. It is the goal of this international program to fulfill this need. An international program provides a forum for experts around the world to exchange ideas, and significantly increases the prospects of acquiring the necessary data soon.

Turkey Flat Experiment

The California Department of Conservation's Division of Mines and Geology (DMG) has, among other mandates, the responsibility to look after the interest of the State and its people with regard to seismic and geologic hazards and promote safe utilization of the state's terrain. Safety analyses of critical facilities such as nuclear power plants, liquid natural gas repositories, and hospitals, as well as provision of hazard information to local governments for planning and development, require application of state-of-the-art techniques in predicting ground motion expected from future earthquakes; however, contemporary methods have not been thoroughly validated. When asked why microzonation has not been implemented in the U.S., the answer is often: "if you ask ten different experts how the ground might shake at a specific site during an earthquake, you will get ten different answers." We see a strong need to identify those methods that are reliable and those that are not, and to establish guidelines and procedures that insure repeatability, in order to effectively carry out our mandates. As a consequence, we have established a test area at Turkey Flat, California, where a series of experiments will help answer this need.

Our general perceptions and experiment objectives echo those of IASPEI/IAEE's Joint Working Group. In their first workshop, held

during the XIX Assembly of the International Union of Geodesy and Geophysics in Vancouver, British Columbia, Canada in August of 1987, a resolution was passed incorporating the experiment at Turkey Flat into the international program.

The principal objectives of the Turkey Flat Experiment are to systematically test and compare all methods of estimating the influence of local geology on ground motion during earthquakes, in order to determine the reliability and cost effectiveness of each. Secondary objectives are to generate a data base for the improvement of these methods, or the development of new methods, and to address the long-standing debate on the linearity of site response. The approach is to collect high quality weak and strong ground motion data, and geotechnical data, and carry out a series of "blind predictions." Experts from around the world are invited to use their preferred method and the acquired data to predict ground motion at locations where the actual response will be known but held in confidence until all predictions have been submitted.

The experiment is being conducted in a number of phases, and this report addresses phase IV, Weak-Motion Prediction. This report presents the observed seismic response of the valley to the test event in the same format as the requested predictions. A comparison of prediction results among one another and with observations will be presented in Report 5, Turkey Flat, USA, Site Effects Test Area, Weak-Motion Test: Statistical Analysis of

Submitted Predictions. A more thorough analysis of observed response from multiple events will be presented in Report 6, Turkey Flat, USA, Site Effects Test Area, Weak-Motion Test: Observations and Modelling. These reports will be available late 1990.

This report presents the observed weak-motion response of Turkey Flat for comparison with predictions, and includes 1) tables of peak values of displacement, velocity, and acceleration, and 2) plots and digital files of Fourier amplitude spectral ratios, time histories, and pseudovelocity response spectra in exactly the same format as requested for the predictions. The organization of the report presents the prediction plan first for reference, the tables of peak values second, acceleration time histories third, pseudovelocity response spectra fourth, and Fourier amplitude spectral ratios last. Digital files of these response parameters are provided on either 360K DOS-compatible diskettes or on a magnetic tape.

WEAK-MOTION PREDICTION PLAN

GROUND MOTION PREDICTION PLAN

I. Instrument Layout:

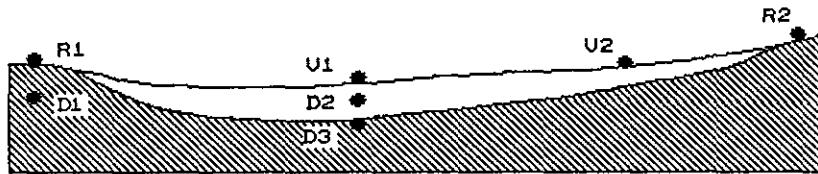


Figure 1

II. Ground Motion Predictions:

Table 1. Weak-Motion and optional arbitrary strong-motion tests:

Prediction	Required ¹	optional ²
1. Fourier Amplitude Spectral Ratios.	1) Ξ_i/R_1 given R_1 (where Ξ_i means $D_1, D_2, D_3, V_1, V_2, R_2$). 2) $V_1/D_3, D_2/D_3$ given D_3 .	1) Ξ_i/R_1 given R_1 (where Ξ_i means $D_1, D_2, D_3, V_1, V_2, R_2$).
2. Acceleration Time-Histories.	1) V_1 given R_1 . 2) V_1 given D_3 .	1) V_1 given R_1 .
3. Psuedovelocility Response Spectra (5% damped), and peak values of velocity, acceleration, & displacement.	1) Ξ_i given R_1 (where Ξ_i means $D_1, D_2, D_3, V_1, V_2, R_2$). 2) V_1, D_2 given D_3 .	1) V_1, D_2, D_3 given R_1 .

¹ Predictions must be done using the standard model, and can optionally be done for a participant-provided preferred model. Only horizontal components of motion are requested.

² Participant given largest horizontal component of the Temblor station record of 1966 Parkfield Earthquake.

TABLES OF OBSERVED PEAK GROUND MOTION PARAMETER VALUES

TABLE 2
**OBSERVED PEAK VALUES
 GIVEN INPUT ROCK MOTIONS AT R1**

Sensor Location		Acceleration (um/sec/sec)		Displacement (um)
V1	N	318.236	10.099	0.4507
	E	473.822	12.644	0.4659
V2	N	518.602	13.164	0.6958
	E	849.283	17.581	0.5924
D1	N	121.359	4.636	0.3157
	E	198.965	6.176	0.2757
D2	N	214.632	7.921	0.4422
	E	320.798	9.207	0.4164
D3	N	135.996	5.582	0.3858
	E	194.906	5.899	0.3242
R2	N	213.562	6.261	0.3219
	E	220.054	5.782	0.3604

TABLE 3
**OBSERVED PEAK VALUES
 GIVEN INPUT ROCK MOTIONS AT D3**

Sensor Location		Acceleration (um/sec/sec)	Velocity (um/sec)	Displacement (um)
V1	N	318.236	10.099	0.4507
	E	473.822	12.644	0.4659
D2	N	214.632	7.921	0.4422
	E	320.798	9.207	0.4164

OBSERVED ACCELERATION TIME HISTORIES

Figure 1a: Standard Time History Accelerogram:

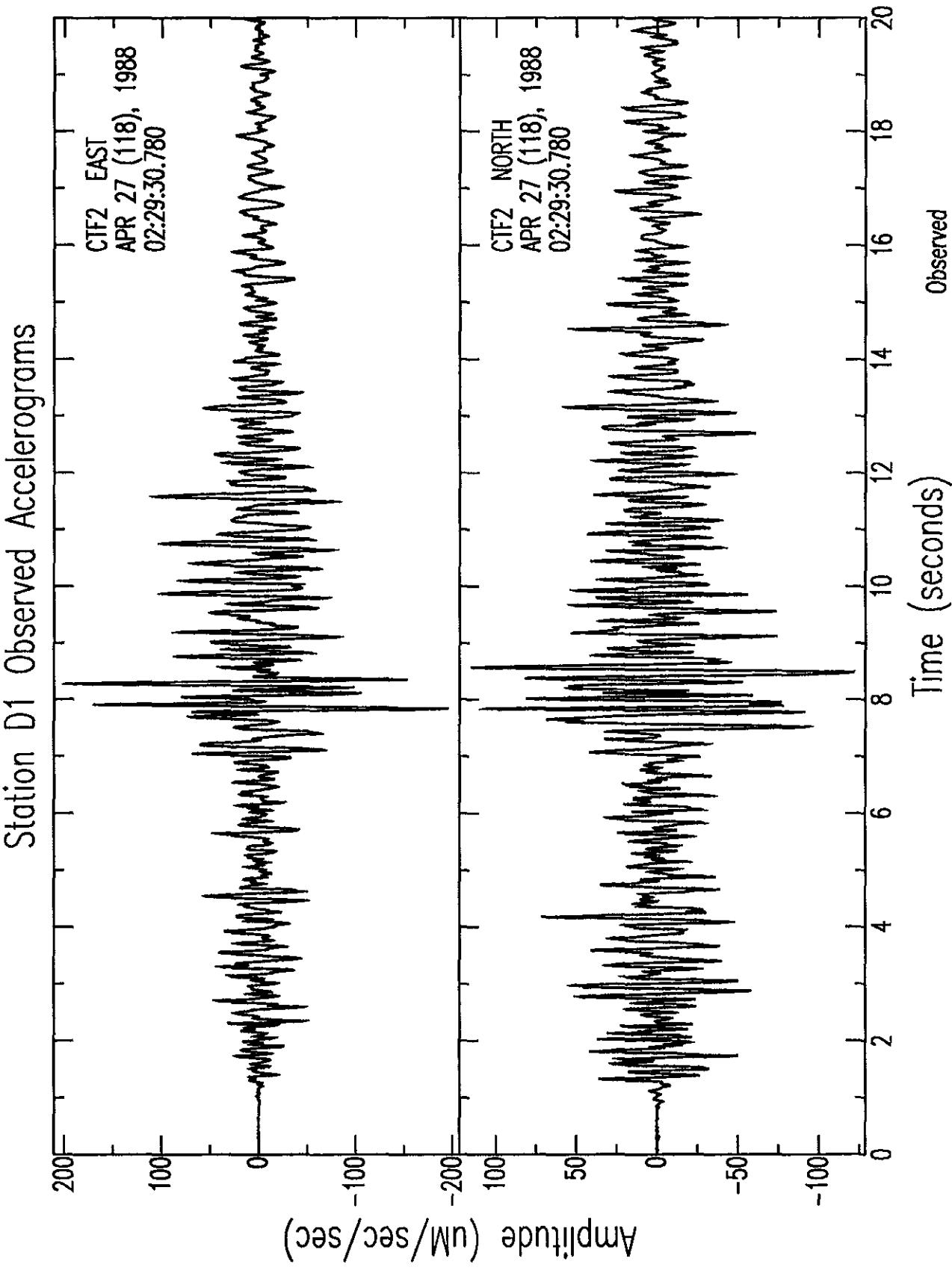


Figure 1b: Standard Time History Accelerogram:

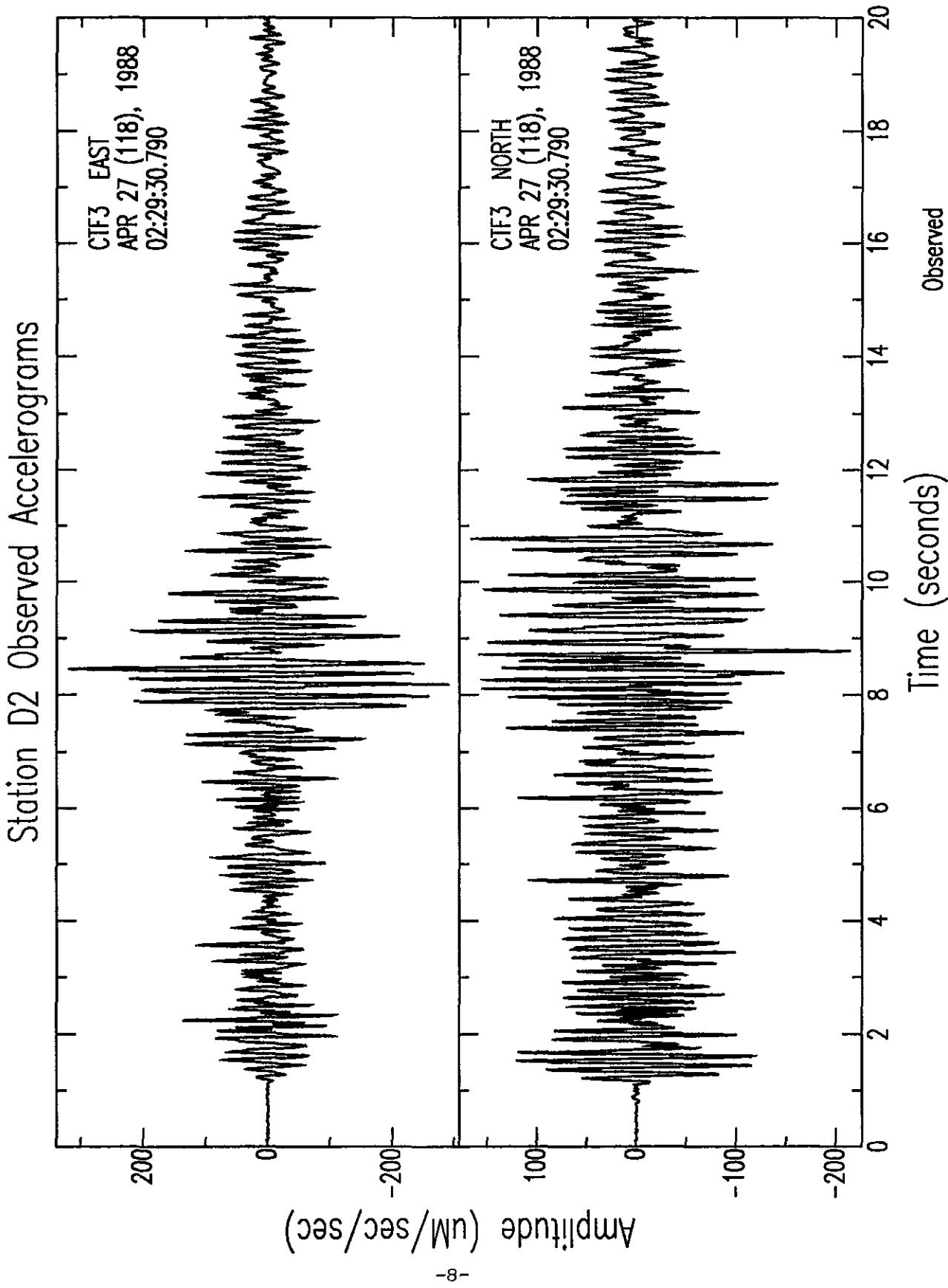


Figure 1c: Standard Time History Accelerogram:

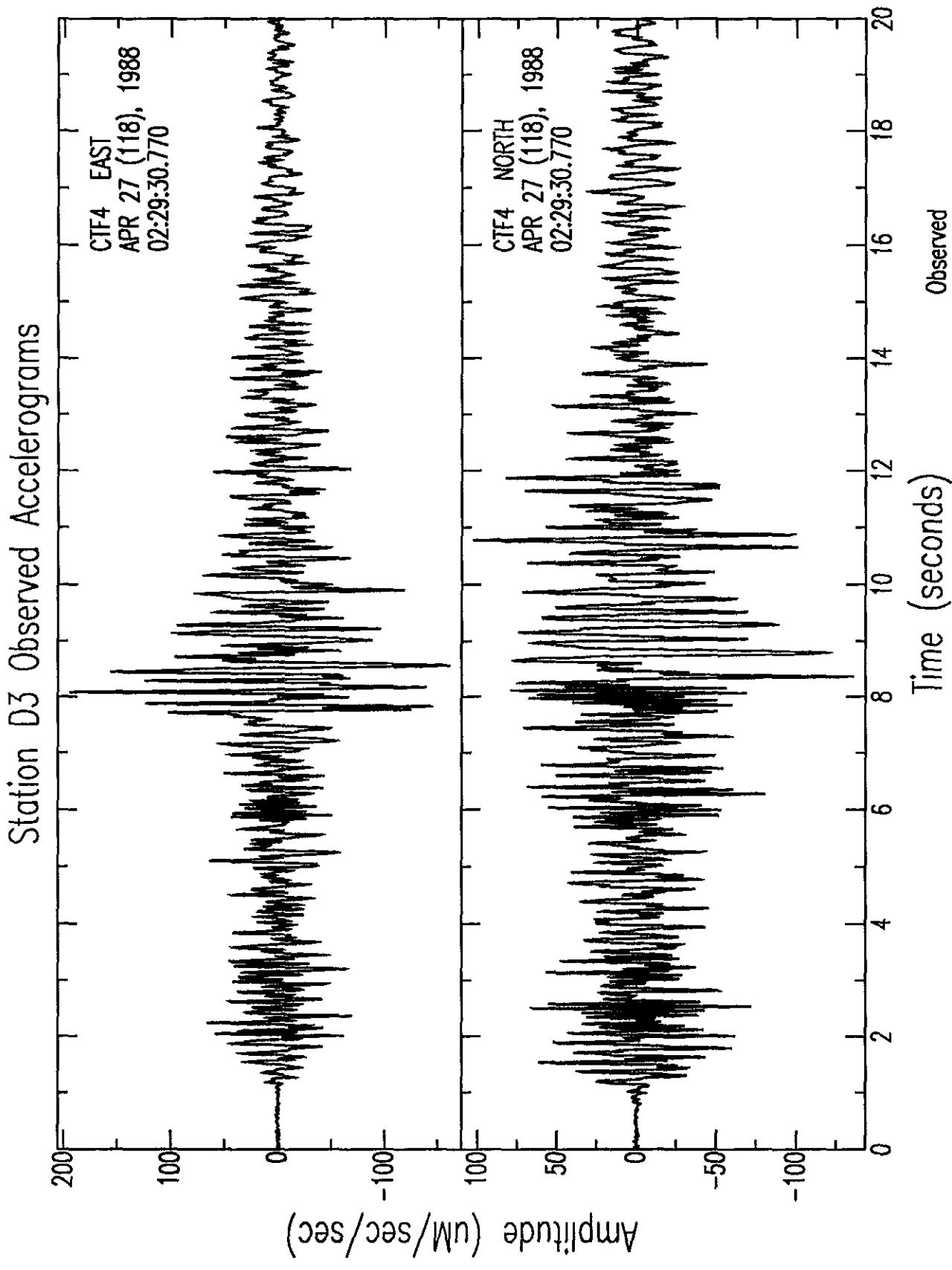


Figure 1d: Standard Time History Accelerogram:

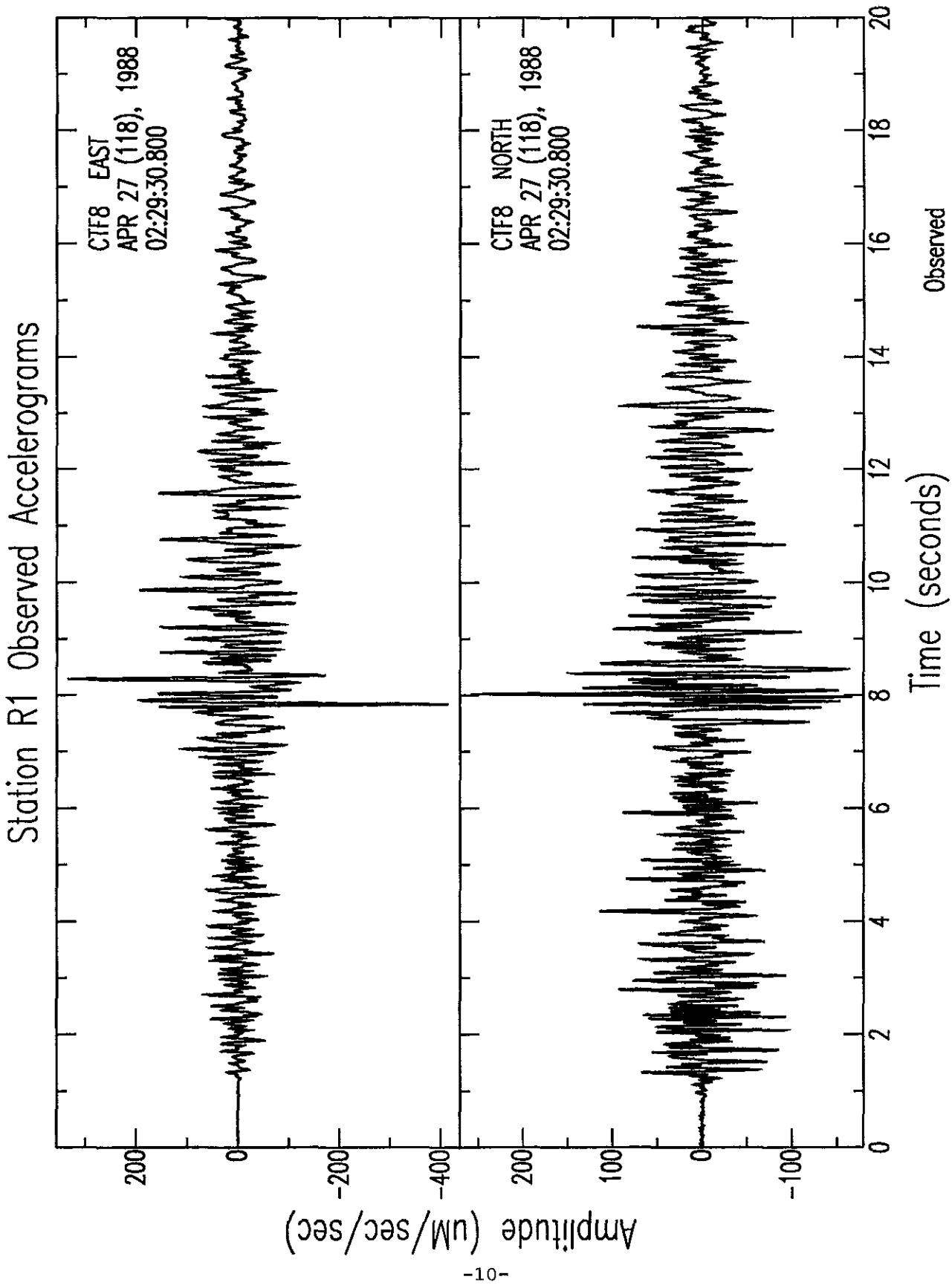


Figure 1e: Standard Time History Accelerogram:

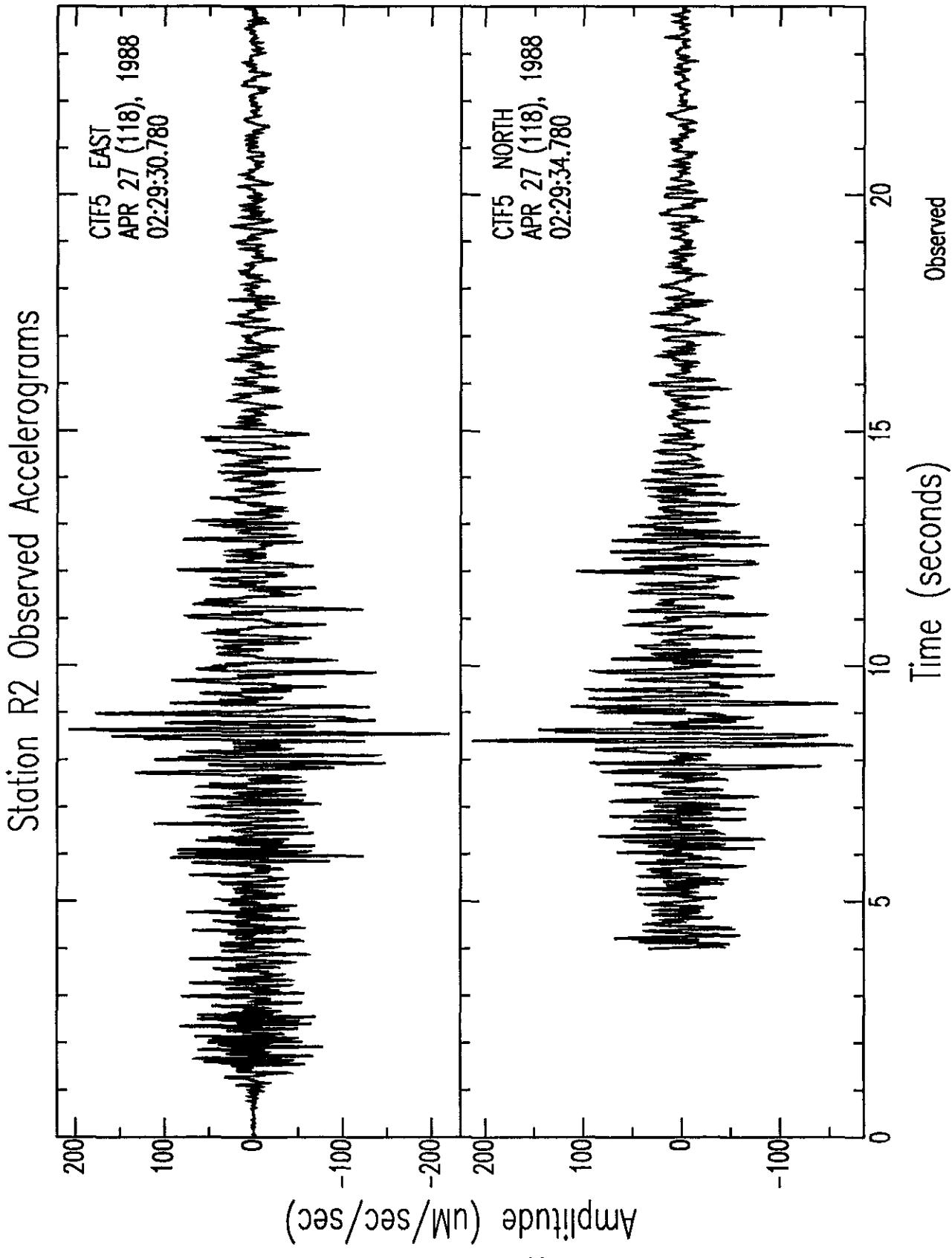


Figure 1f: Standard Time History Accelerogram:

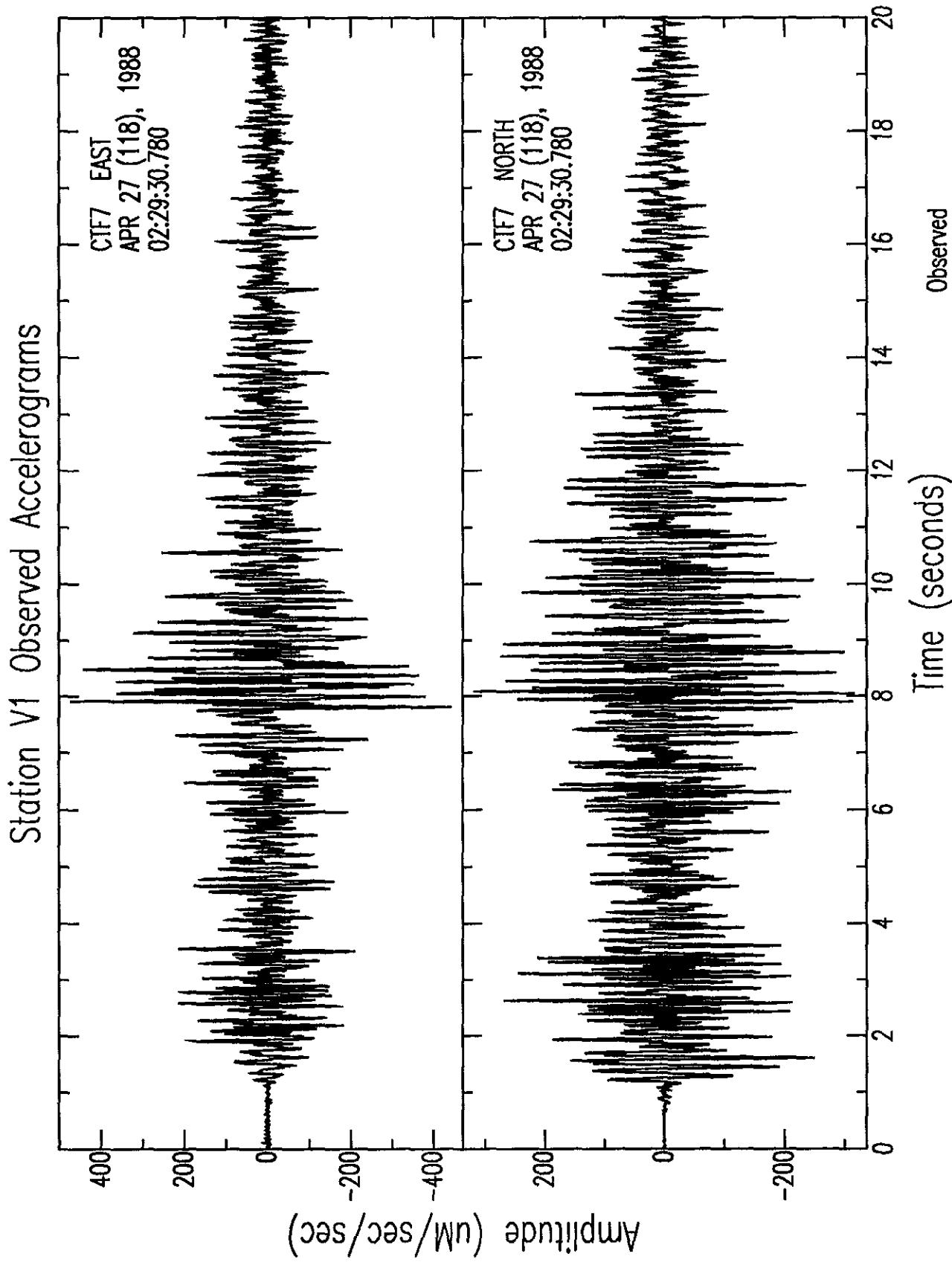
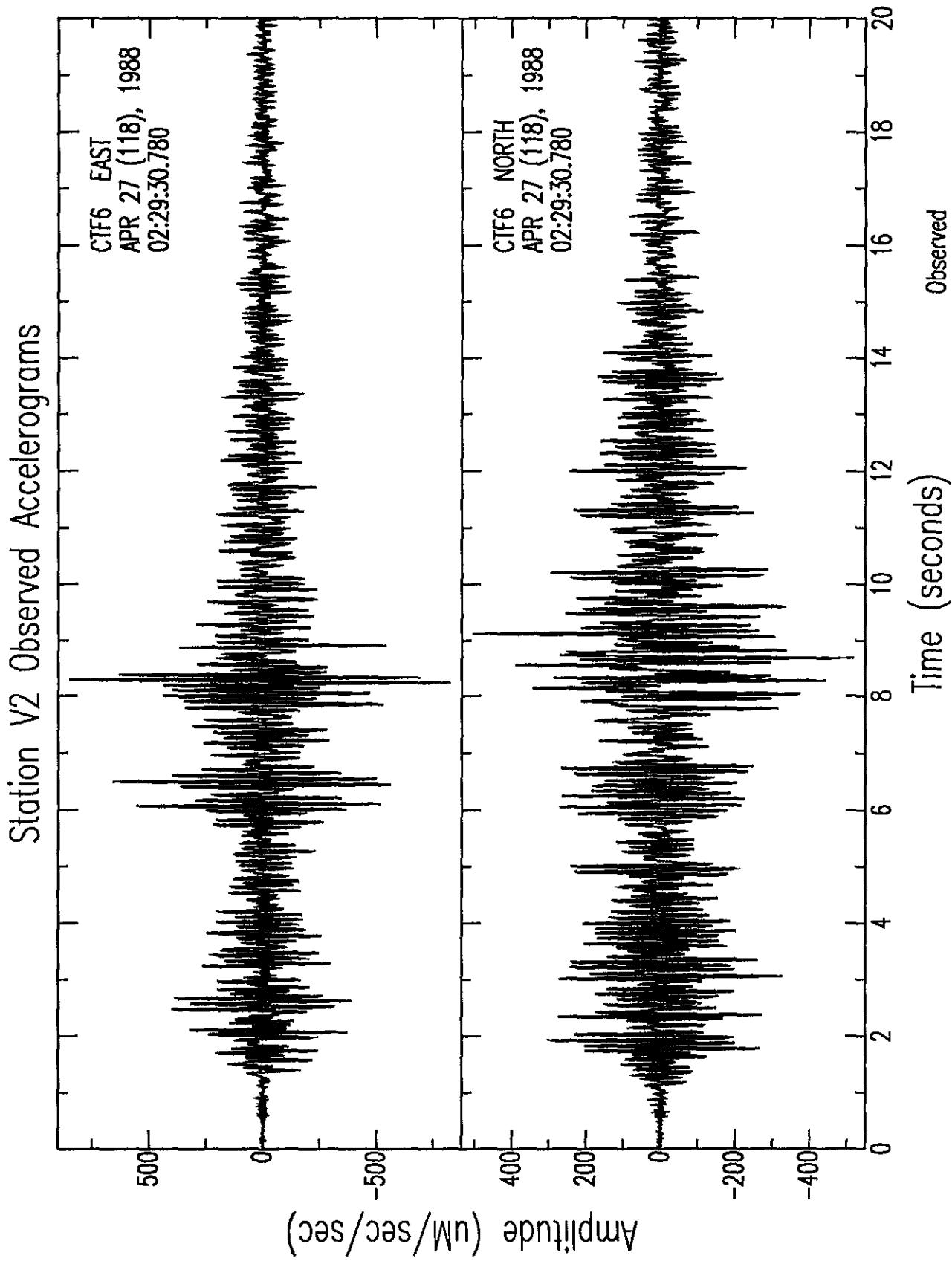


Figure 1g: Standard Time History Accelerogram:



OBSERVED PSEUDOVELOCITY RESPONSE SPECTRA

Figure 2a: Standard Response Spectra:
Station D1 Observed Response Spectra

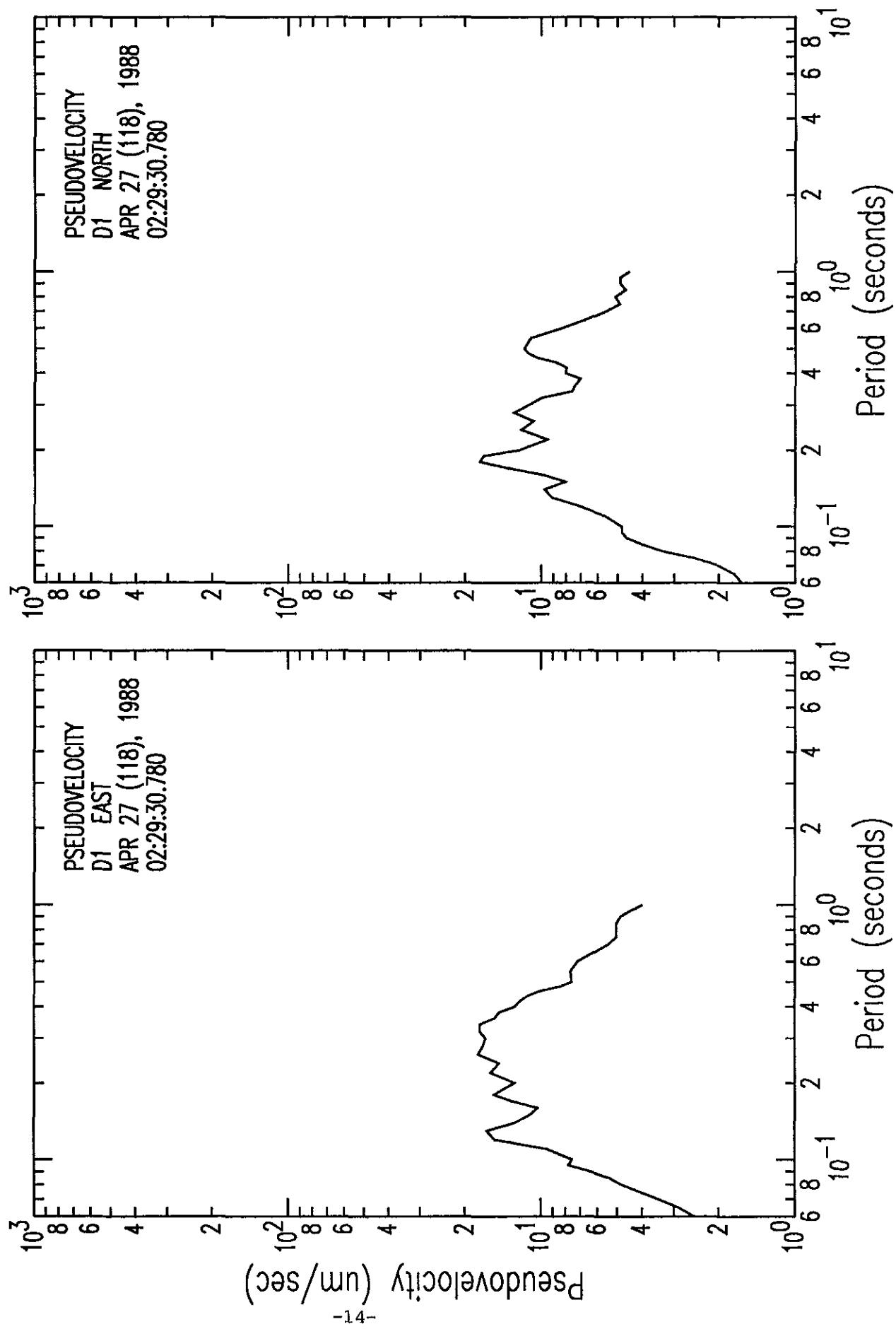


Figure 2b: Standard Response Spectra:
Station D2 Observed Response Spectra

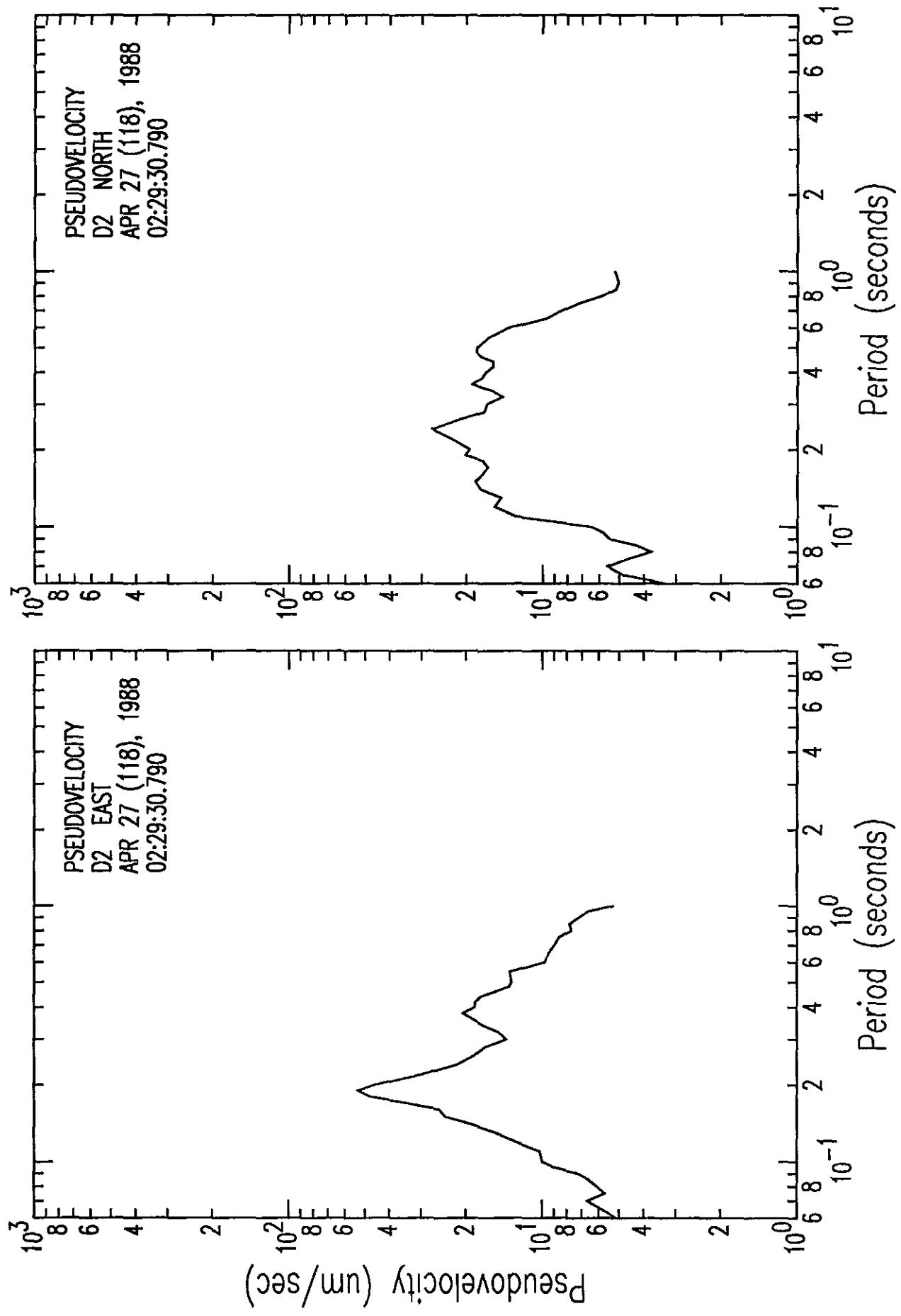


Figure 2c: Standard Response Spectra:
Station D3 Observed Response Spectra

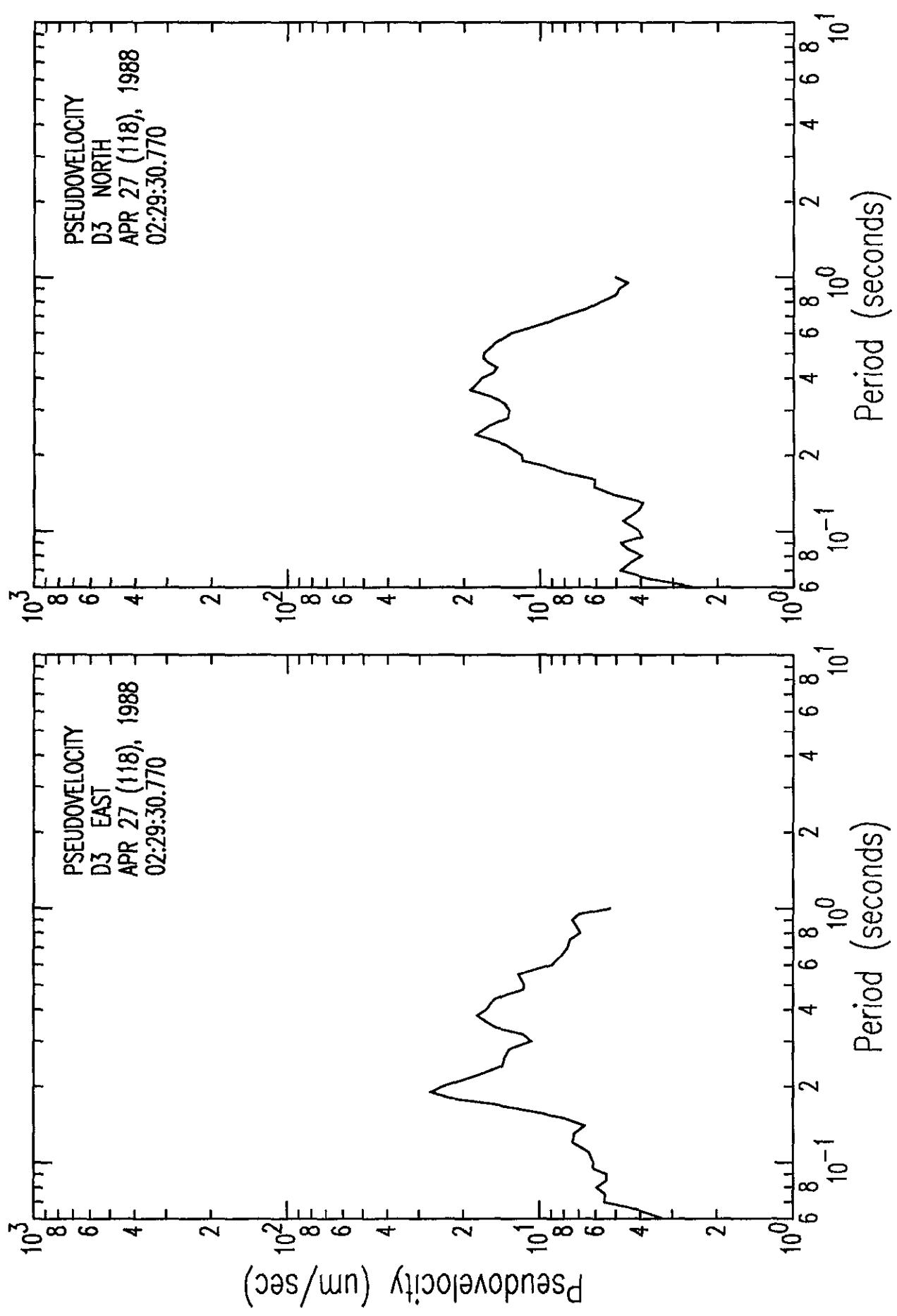


Figure 2d: Standard Response Spectra:
Station R1 Observed Response Spectra

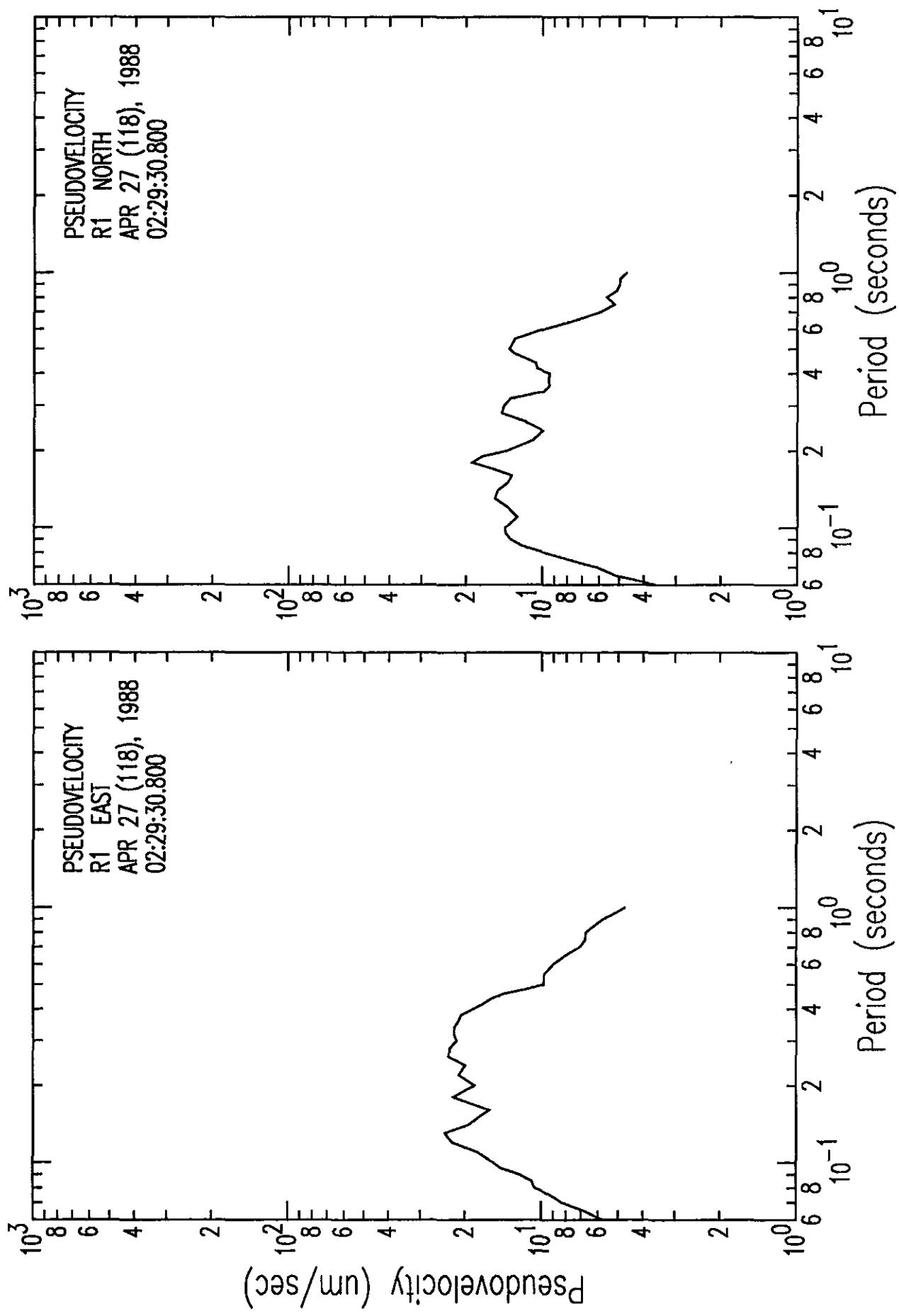


Figure 2e: Standard Response Spectra:
Station R2 Observed Response Spectra

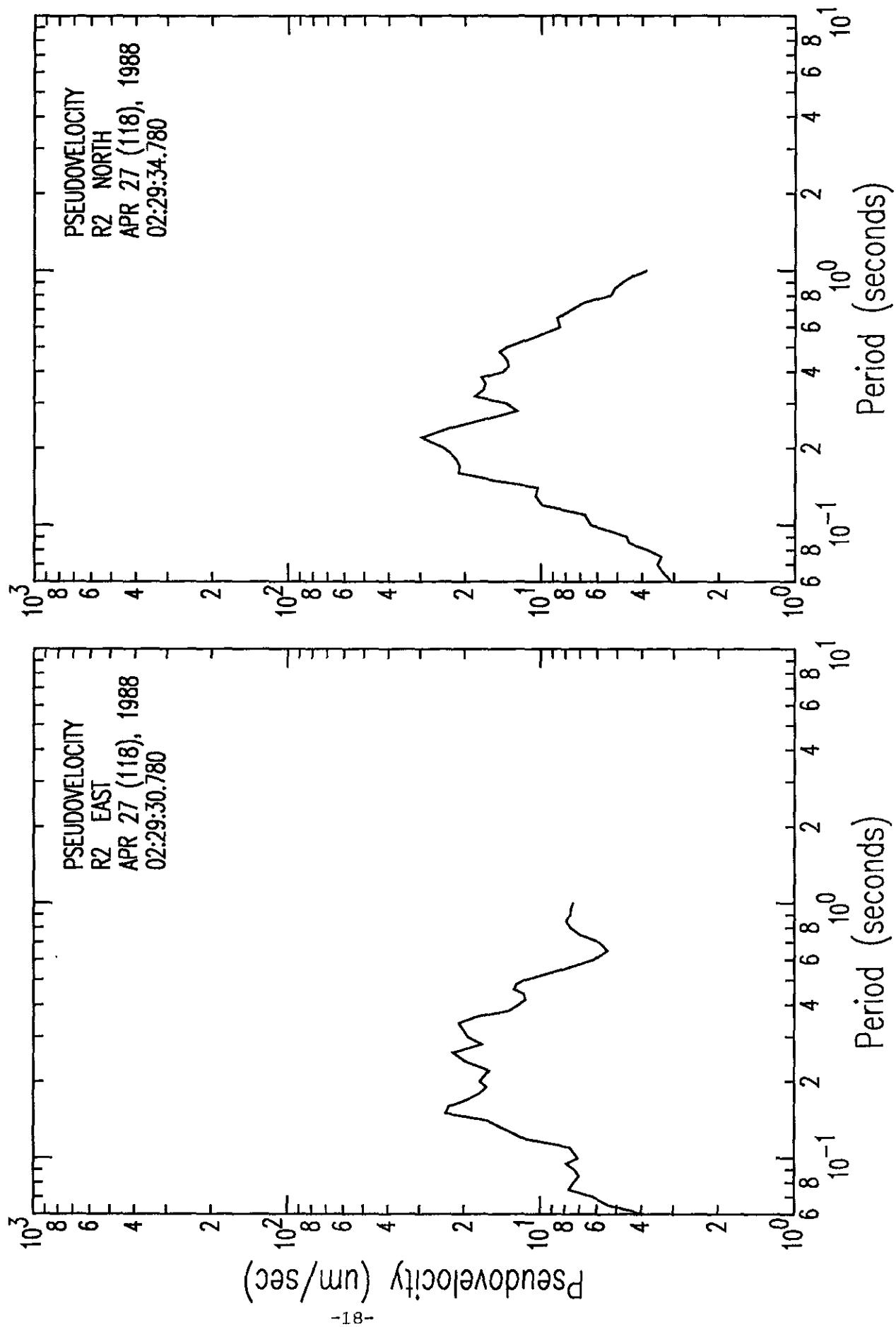


Figure 2f: Standard Response Spectra:
Station V1 Observed Response Spectra

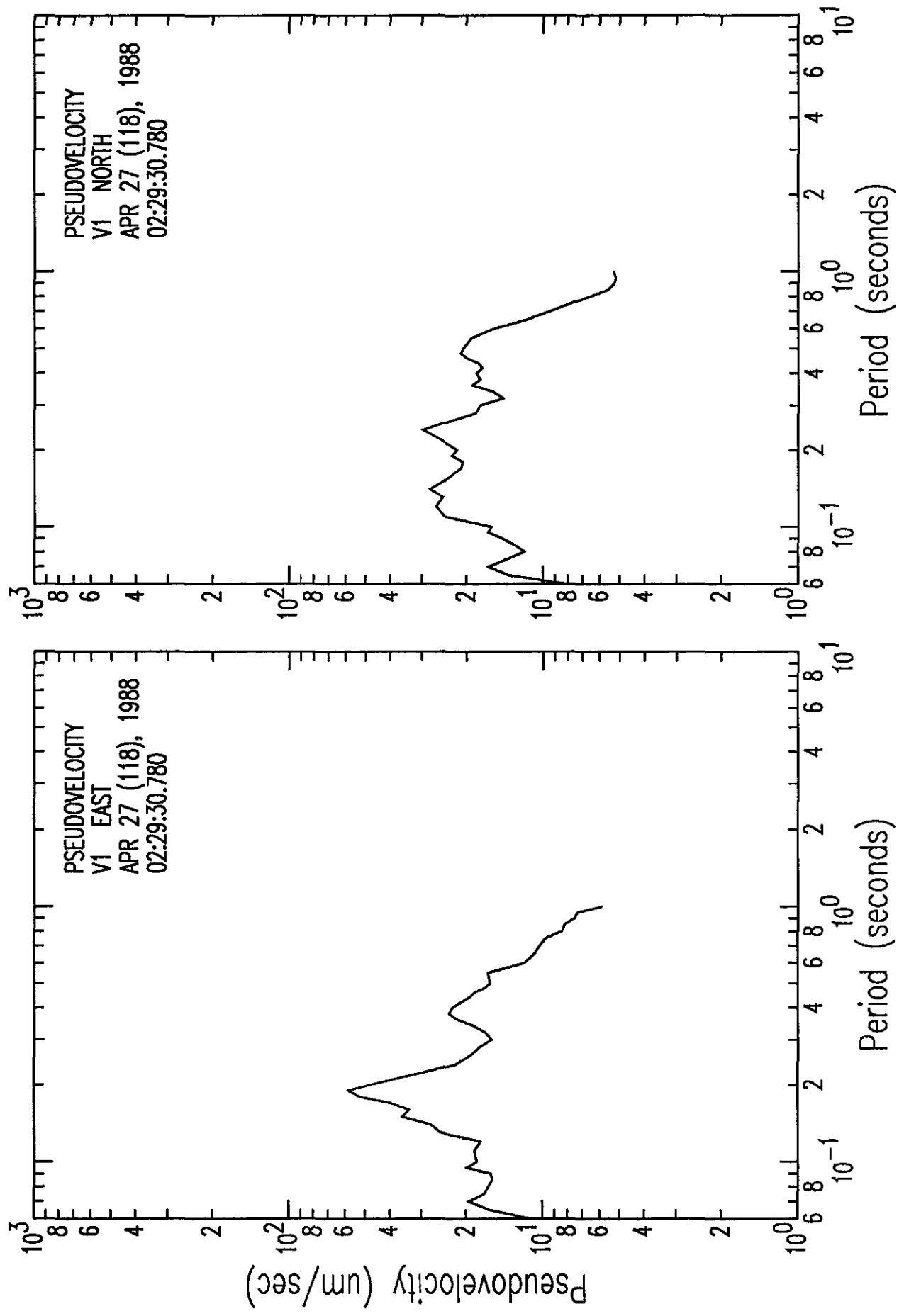
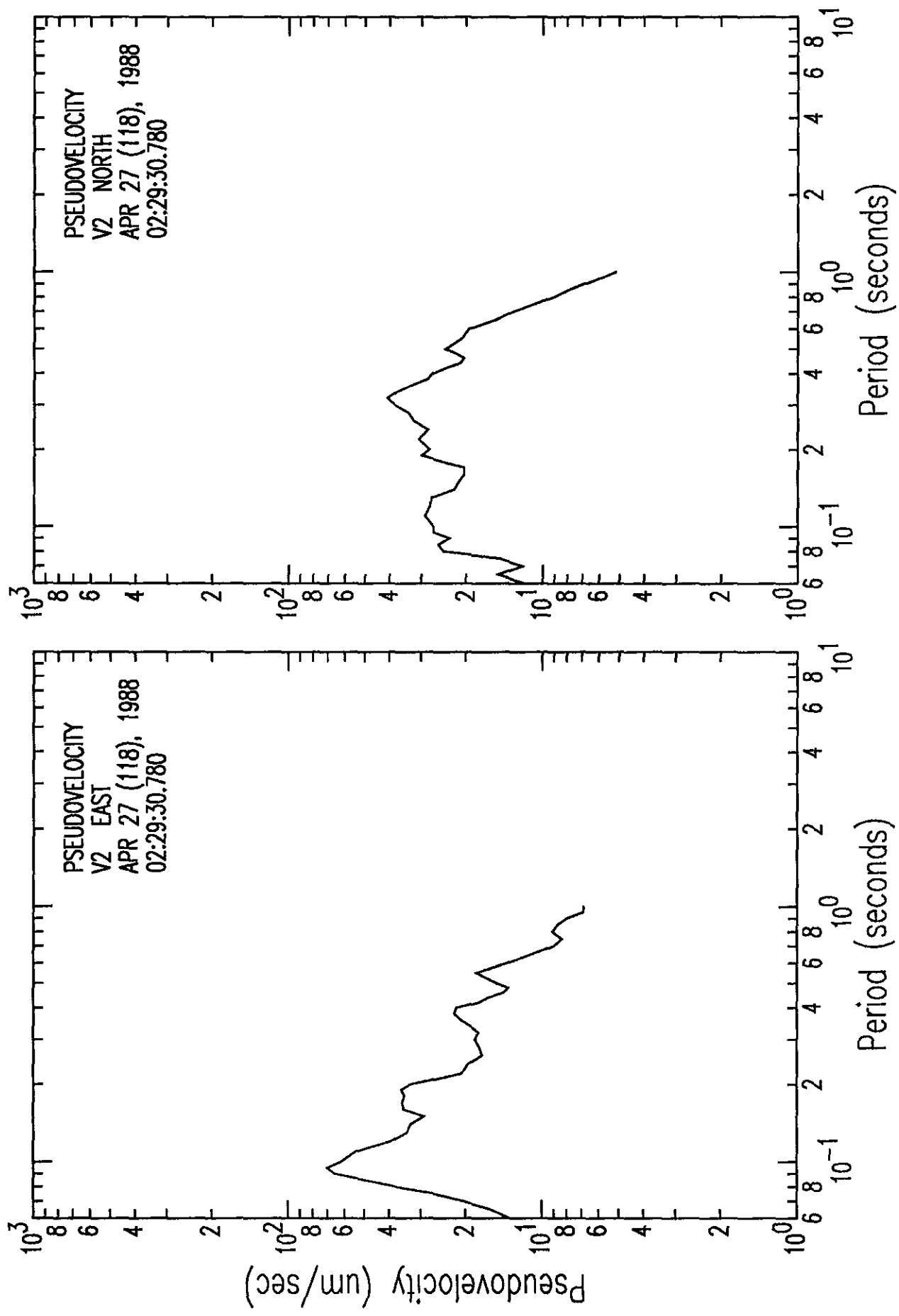


Figure 2g: Standard Response Spectra:
Station V2 Observed Response Spectra



OBSERVED FOURIER AMPLITUDE SPECTRAL RATIOS

Figure 3a: Standard Fourier Spectral Ratio Plot:

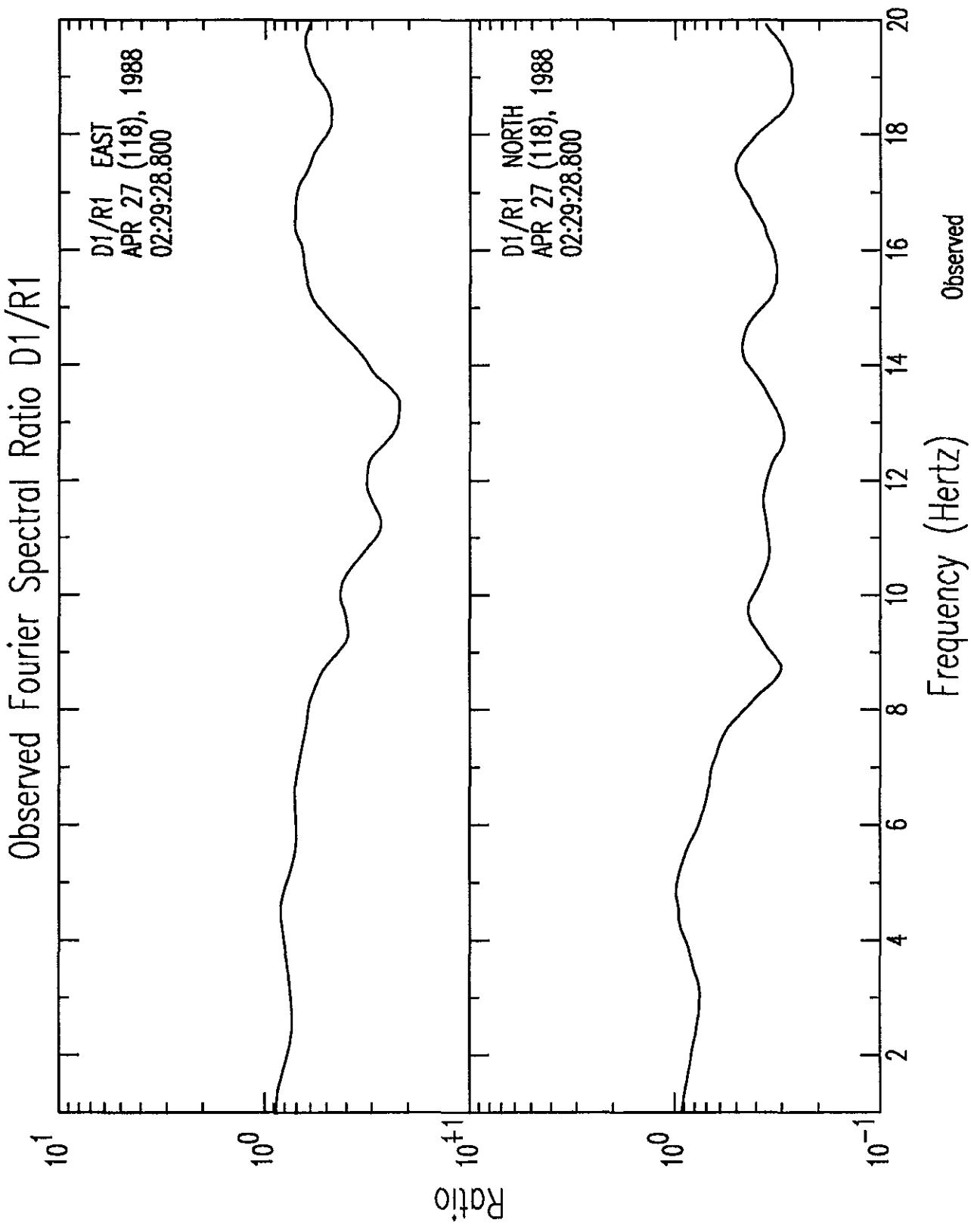


Figure 3b: Standard Fourier Spectral Ratio Plot:

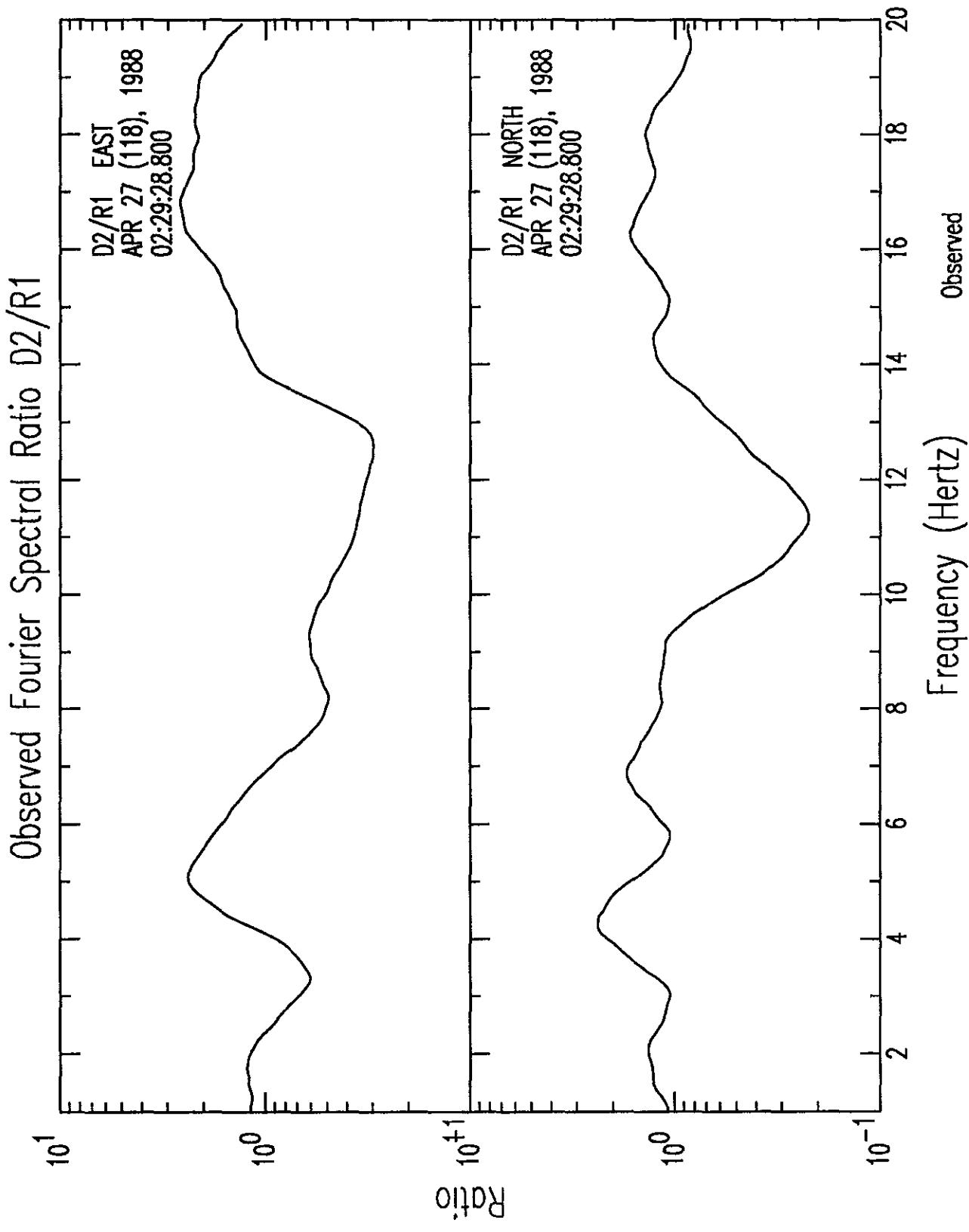


Figure 3c: Standard Fourier Spectral Ratio Plot.

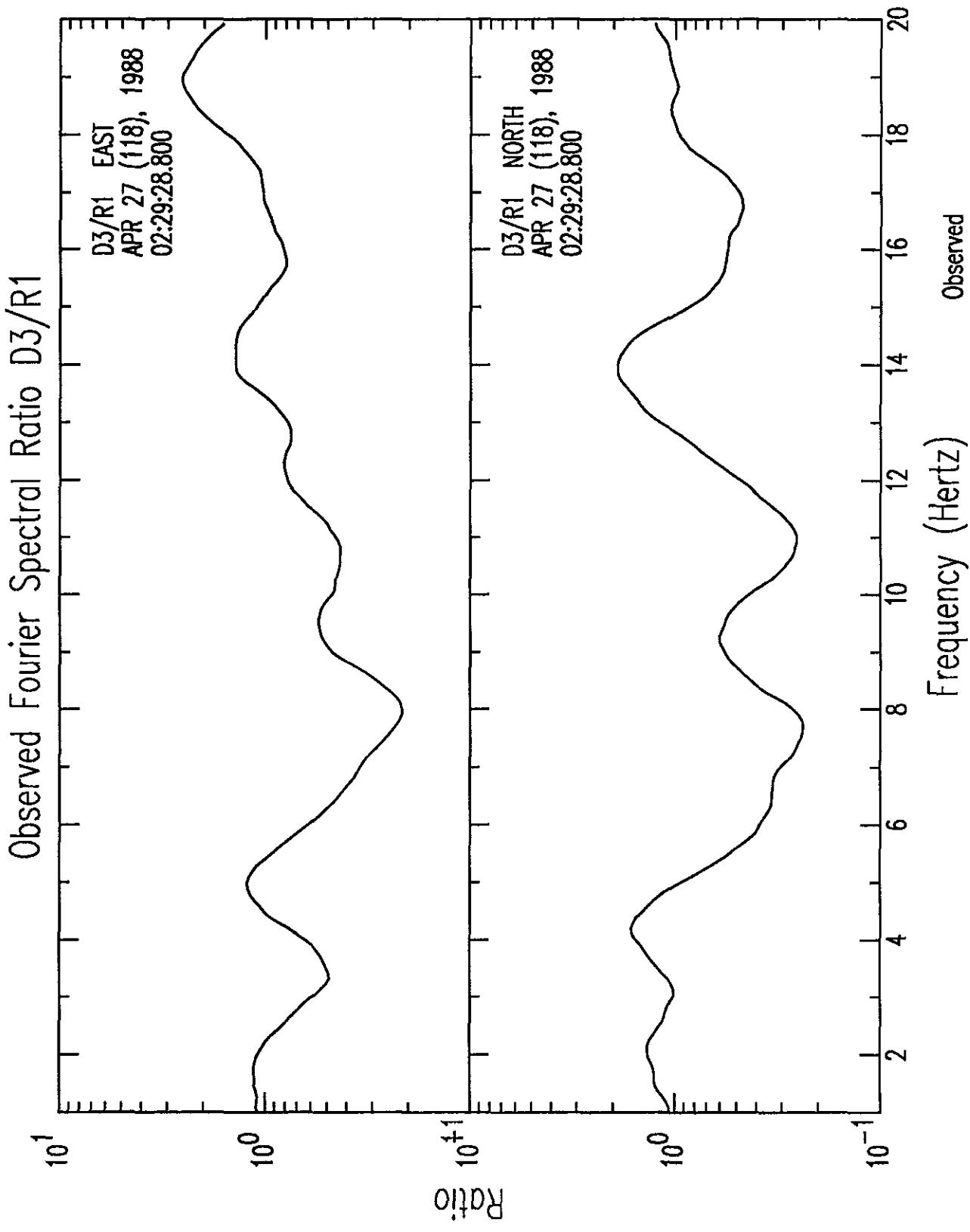


Figure 3d: Standard Fourier Spectral Ratio Plot:

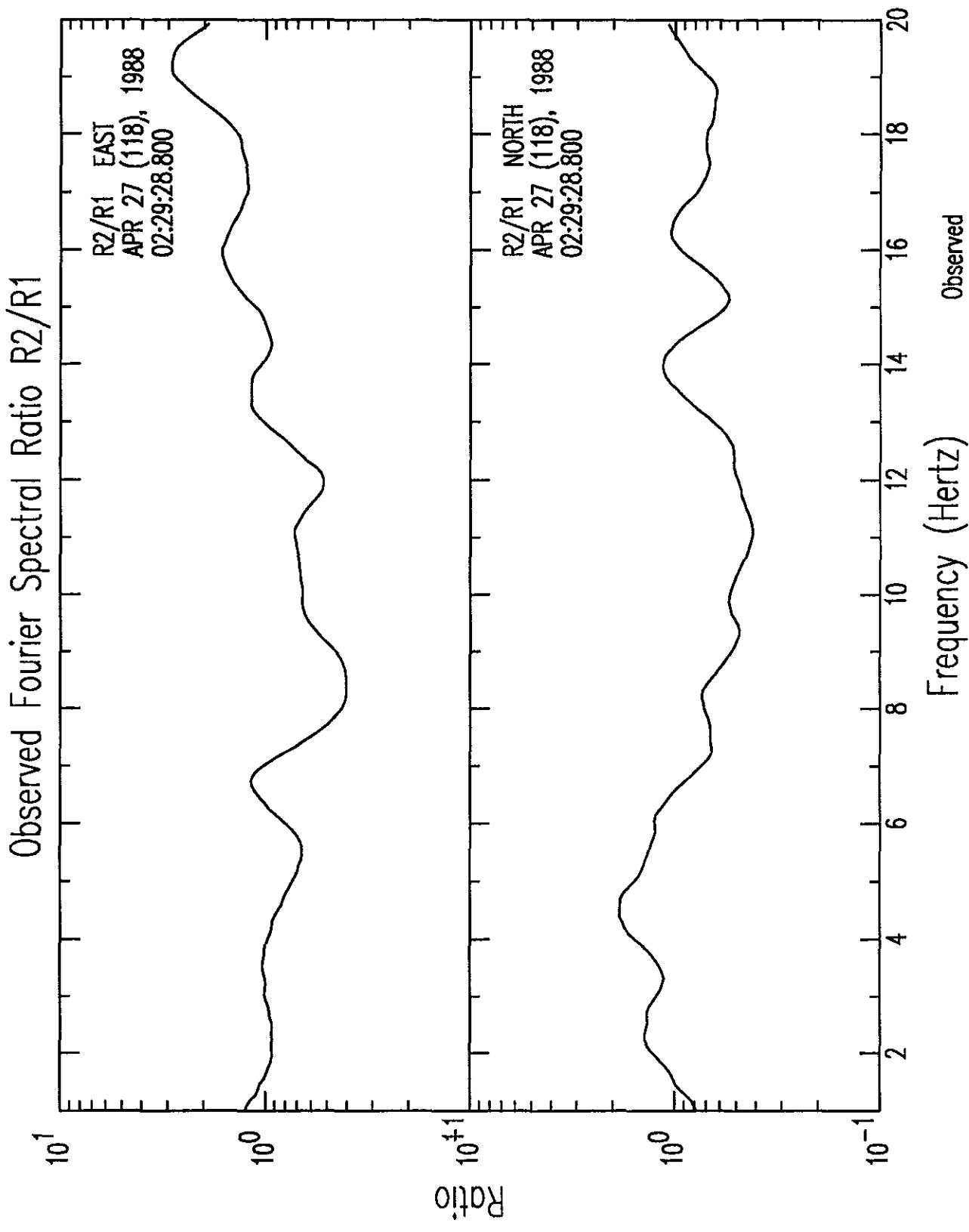


Figure 3e: Standard Fourier Spectral Ratio Plot:

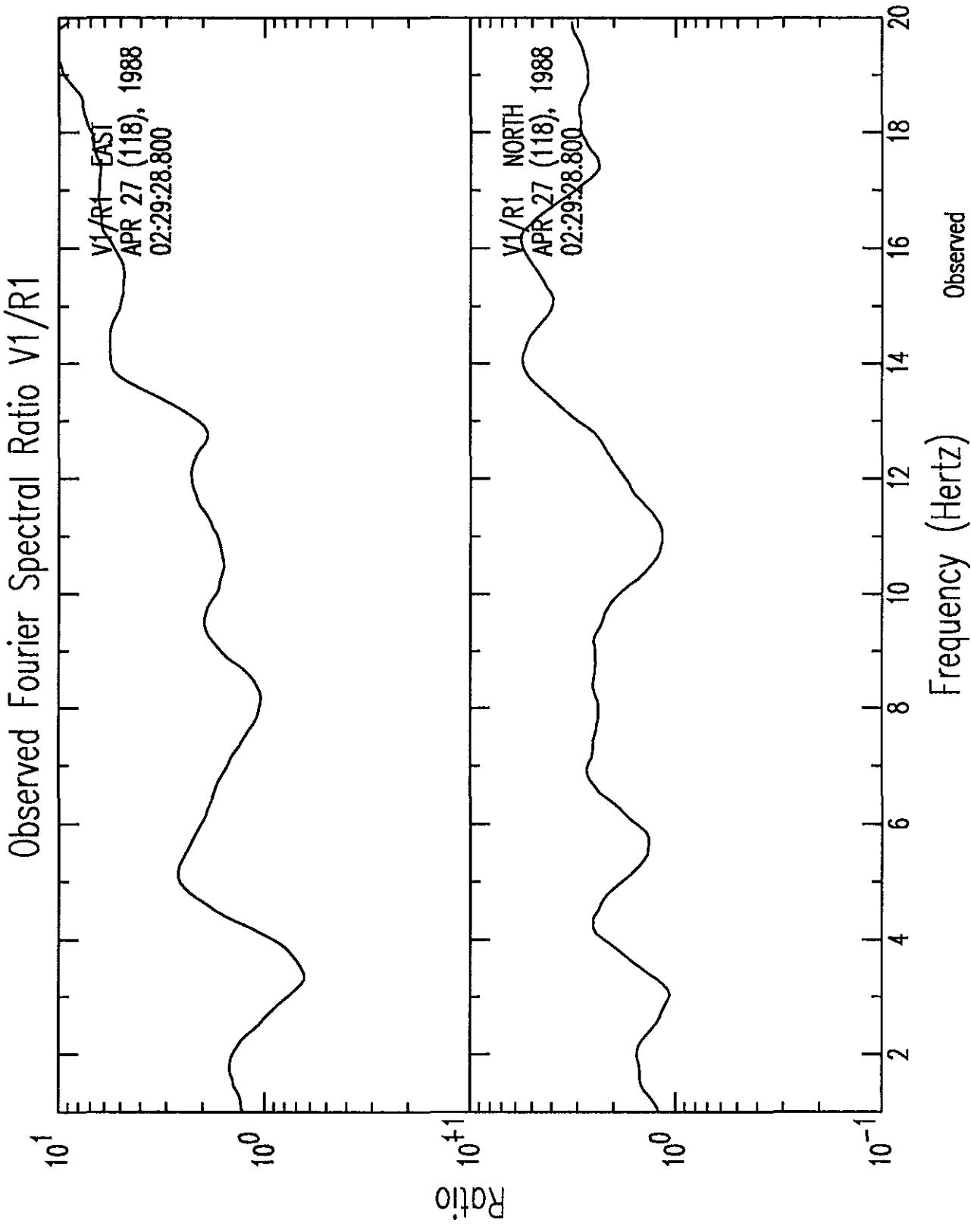


Figure 3f: Standard Fourier Spectral Ratio Plot:

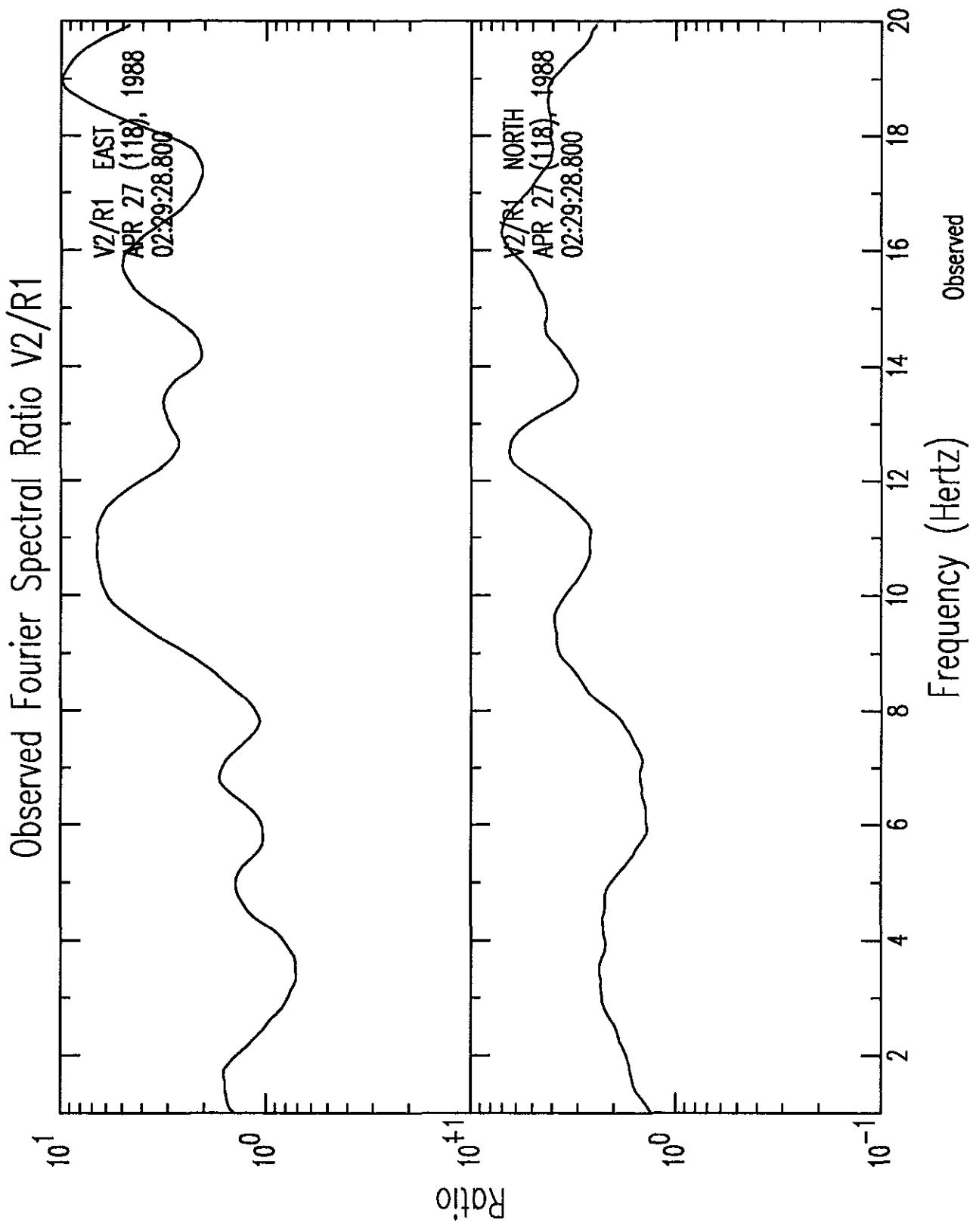


Figure 3g: Standard Fourier Spectral Ratio Plot:

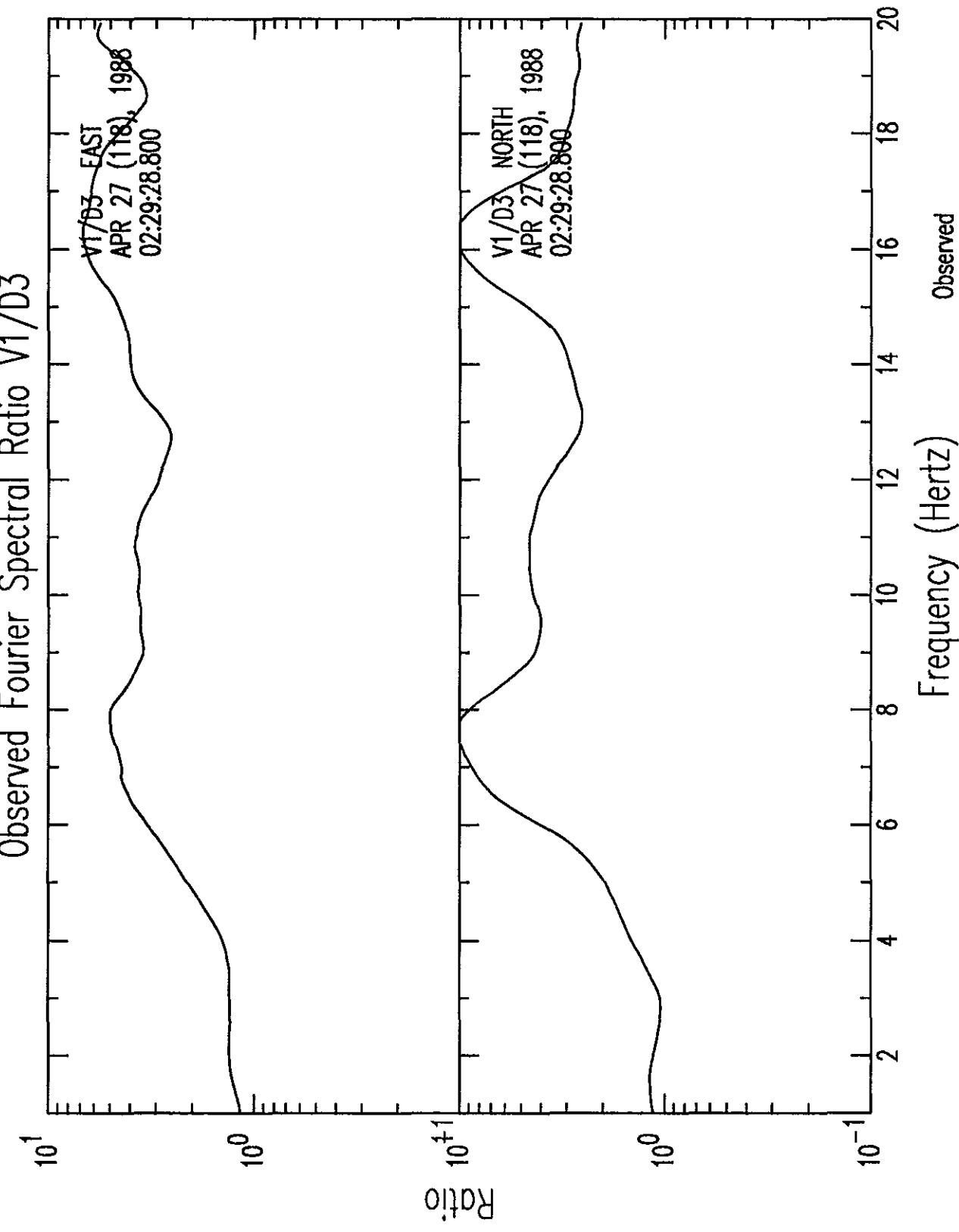


Figure 3h: Standard Fourier Spectral Ratio Plot:

